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INVENTORS & INVENTIONS

COMPUTERS

DAVID WRIGHT

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Computers [redacted]

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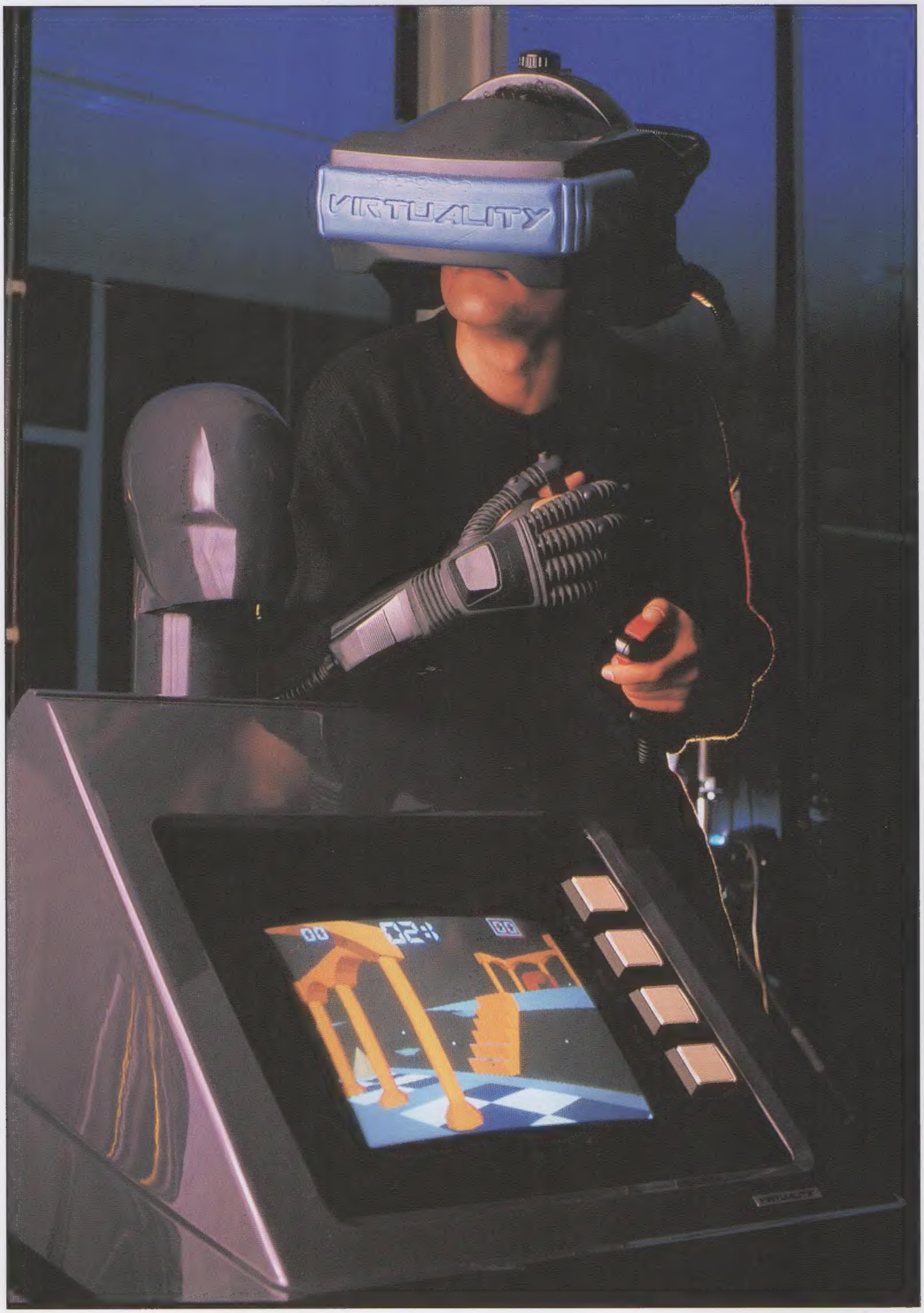
COMPUTERS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(Cover) An engineer trains on a computer system that simulates the controls in a nuclear power station.

(Frontispiece) Playing a virtual reality computer game equipped with a headset and data glove.

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Chapter 1
Before Electronics

The twelve-year-old girl was worried. So was her family. For several weeks she had suffered occasional, frightening fainting spells — spells that caused her to collapse without warning on the school playground or while eating dinner at home. What could be wrong?

The family doctor examined her, ordering x-rays and drawing blood. Nothing turned up. After talking with a neurologist, a brain doctor, the family physician told the girl's parents that she should be examined with a large, complex piece of machinery. This scan, said the doctor, could provide information like no other kind of exam.

The child and her parents arrived at a large hospital in a nearby city. The girl lay on a narrow table, and she and the table were inserted into a doughnutlike hole in a million-dollar machine. This computerized tomography (CT) scan would perform several amazing feats.

The costly device scanned the girl's head in cross sections, moving around her as she lay still. These "slice" pictures were so thin that it would have taken one hundred stacked cross sections to move from the top of her head to her chin. The scans went into a computer. A trained operator improved each view, reconstructing fuzzy-looking areas and adding colors to various bones, organs, and vessels with the aid of the computer's program. When the neurologist studied these "slices" on a monitor, he saw why the child suffered fainting spells.

A small cancer, about the size of a marble, had grown between the two halves of her brain. After viewing it in many

...vers and ensuring that surgery could work, the physician ...xplained matters to the girl's parents. The operation was quick... scheduled and, thanks to a computer, the cancerous tumor was ...xactly where the CT showed it to be. It was removed without ...ther damage. The fainting spells disappeared, and the girl got on with a normal life.

During a CT brain scan, a circular scanner directs x-ray beams through a patient's head from all around. These scans differentiate between bone, fat, and muscle. Radiographers can analyze the images produced by the scanner on their computer screens.

Computerized tomography is only one of the dramatic, modern uses of computers. Computers help land airplanes, aim missiles, figure out which typefaces might be best for a brochure, help cars get better gas mileage, run video games, manage telephone systems, and influence our lives in countless other ways.

Yet the computer story is not a completely modern one. In fact, it began thousands of years ago. . . .

Some Beads, Some Wires, a Frame

Long before computers were invented, humans realized the need for them. People learned very early to do simple arithmetic in their minds. But complex problems were difficult — they involved keeping track of one or more things while solving others. The path toward a modern computer began about five thousand years ago, in what is now China, with the abacus. Made of rows of beads on wires in a frame, the hand-held, mechanical abacus helped solve tough arithmetic problems. It is still used by tradespeople today in the Middle and Far East. The movable beads represented one, ten, one hundred, one thousand, and so on.

The abacus has been in use across Asia and Europe for thousands of years. It remained the best calculating machine available until the seventeenth century. This is a nineteenth-century Chinese abacus.

The first mechanical arithmetic machine was put together by a young Frenchman who wanted to help his father do business. In 1642, Blaise Pascal built a device made of wheels with numbers on them that could be moved, causing gears to mesh. The machine worked much like a car odometer (the little row of numbers embedded in a car speedometer that tells how many miles the vehicle has been driven). Like the odometer, Pascal's device showed a total.

But Pascal's machine could only add. Thirty years later, a German named Gottfried Leibnitz put together a device that could multiply

and divide. Unreliable and difficult to operate, this stepped reckoner was the best mathematical machine there was until 1820, when an improved reckoner was available that could add, subtract, multiply, and divide.

Solving Strings of Problems

Such machines could be found in many American and European shops and offices in the 1800s, but that did not mean they were the final answer. In 1835, English inventor Charles Babbage had a greatly improved idea. He saw that a computer should be able to come up with an answer to a problem, then feed that answer back into the device to help solve longer and more difficult problems. His analytical engine had two parts, a calculating section and a storage section. It was even able to print out results — all because of an idea Babbage borrowed from a loom invented a few years earlier in France!

Jacquard invented this loom at the beginning of the nineteenth century. Punched cards, top right, gave the instructions needed for the loom to weave elaborate designs.

Devised in 1801, the Jacquard loom was one of many clever inventions unveiled during the nineteenth-century Industrial Revolution. Fed with precisely punched cards that represented patterns, the loom mechanically wove flowers, leaves, and other designs, all at a faster rate than could be done by hand. Babbage made his machine capable of reading the punched holes in cards, just as the loom did. Until just a few years ago, modern electronic computers used the same system to read information off punched cards.

Charles Babbage (1791–1871) and Ada Byron, Countess of Lovelace (1815–1852)

Charles Babbage was born a sickly infant in a London suburb. Fascinated with the inner workings of even the simplest item, young Charles would be handed a new toy but instead of playing with it, he quickly broke it apart to see what was inside!

Babbage entered college and soon disappointed his mathematics teachers — he knew more than they did. He and several brilliant friends started a club called the Analytical Society, where their interests helped revive the study of algebra all across Britain.

In 1823, shortly after seeing his first calculator, Charles began to work on what he called the difference engine. The author of eighty books and father of eight children, Babbage somehow found the time to invent a machine that calculated long and complicated tables of numbers. He called an improved version the analytical engine.

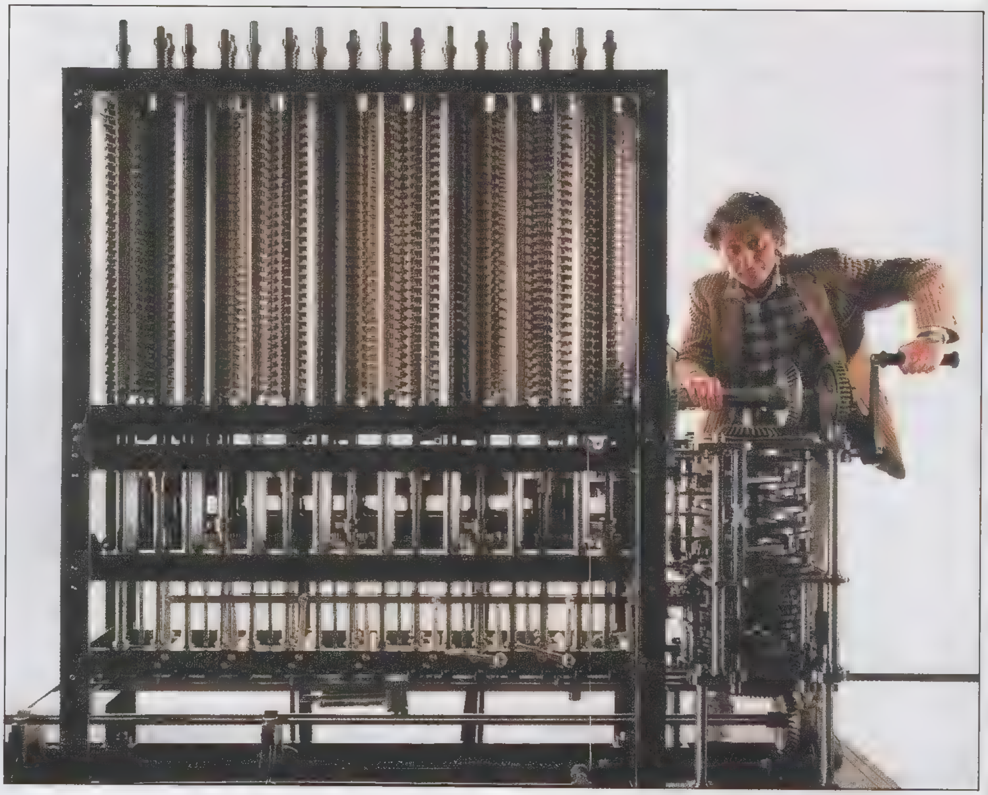
The analytical engine was capable of performing any mathematical function and was programmed with punched cards. It was a true forerunner of the modern computer and was one of the great achievements in science. Charles began to design it in 1834. In an era well before electricity, Babbage nevertheless realized the need for lots of power — he thought his computer would require the use of several steam engines!

Few would have known of Babbage's work without the intelligence of the daughter of the dashing poet and adventurer, Lord George Byron. Ada Byron, Countess of Lovelace, was not only able to appreciate the inventor's devices but could also write well about them.

The two met at a party when Babbage was aged forty-two and Ada Byron was seventeen. Nine years later, Ada translated from the Italian a paper that explained the mathematical thought on which the Babbage engine was based. A capable mathematician herself, she developed a program for the analytical engine and gave Britain its first glimpse at an incredible invention and its strange but talented designer.

Charles Babbage, who was not always an easy person to be around, became lifelong friends with the countess and her husband. Very few other people were able to understand or appreciate his work. Though frail, Ada Byron could explain mathematics very well.

No one dared speak ill of the inventor in front of the countess. Until she died at the age of only thirty-six, she admired him unswervingly. Charles Babbage himself lived to be almost eighty. But by the time of his death, most residents of Britain had forgotten the inventor and his amazing analytical engine.



A modern working model of Babbage's analytical engine in the Science Museum, London, England. Babbage's ideas were not implemented in his time because the technology did not exist for nineteenth-century engineers to put them into practice.

AMAZING FACTS

Charles Babbage is considered a computer pioneer, but he also invented items that would endear him to insurance salespeople, traffic police, private detectives, and railroad engineers. Babbage conceived actuarial tables, which are major reference sources for insurers as they determine the cost of a policy based on age, sex, health, and other variables. He also constructed the first speedometer, invented a skeleton key capable of opening any door, and designed cowcatchers, the metal pieces on trains that push cows and debris off the track.

Oddly enough, Babbage's analytical engine could not have been built in his day. Tools and measuring systems just weren't exact enough. Its design was so sophisticated, with so little margin for error, that a recently built analytical engine needed computer assistance during its construction! Once it was finally assembled, it worked very well.

Counting People

An American got involved half a century after Babbage. Herman Hollerith was a government official who invented cards for census takers (government employees who count the population). The census takers added information to the cards by punching holes in specific spots. The information was recorded by a machine equipped with many metal pins that poked through the punched holes but stopped where no holes existed. Results were exciting — the 1890 census was completed in one-

third the time taken in 1880, even though the U.S. population had grown by almost thirteen million people during the decade! Hollerith later helped start the Computing Tabulating Recording Company, which would become computer giant International Business Machines, or IBM.

The early part of the twentieth century saw real progress in automation. Firms such as the National Cash Register Company in Dayton, Ohio, brought out a mechanical device called a cash register. It allowed small retailers to keep track of all the money they took in and paid out, printing the results on a spool of paper tape. Though hardly a computer, the cash register, along with the adding machine, was to bring enormous improvements in efficiency (and honesty!) to business.

National Cash Register's chief rival became the Computing Tabulating Recording Company. CTR gained many users from 1919 onwards by offering a tabulating machine that, at the flick of a switch, shuffled cards through its inner workings and quickly printed results. But such mechanical advances only proved that what people really wanted was a machine that could think. Fortunately, scientists and mathematicians in several different places during the 1930s were hard at work on just such a machine.

Machinery used to process the 1890 U.S. census results. Battery-operated rods passed through the holes in the punched cards to complete electrical circuits. The dials counted every completed circuit.

Chapter 2
From Tube to Chip

Different people in Europe and North America, mostly unknown to each other, began working during the 1930s on machines that could think. All of them believed that a successful computer would be electrical rather than mechanical. Except for that notion, the inventors had little in common. No single person could be credited with inventing the computer — many different people added to the overall knowledge.

One group tackled the problem at the Massachusetts Institute of Technology. Led by mathematician Claude Shannon, these thinkers realized a connection between logic (reasoning) and numbers. The numbers they had in mind were part of a mathematical system called Boolean algebra. It was a lot like the switching on and off of electrical circuits. Why, researchers asked, couldn't we make a machine think by switching circuits on and off?

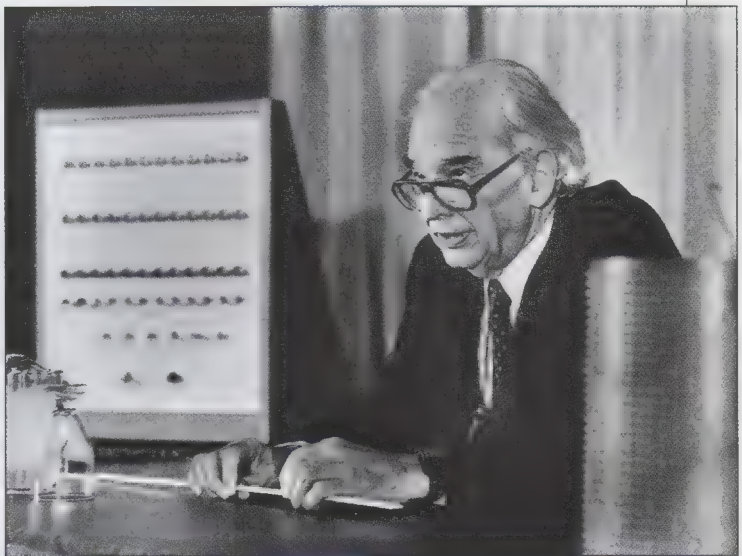
Another inventor, working alone, came as close as anyone to being the father of the American computer. The problem with this high-energy Iowa State College professor, John Atanasoff, was he enjoyed thinking about computers more than building them. However, the mathematics professor and a student did put together an electronic digital computer in 1939. Because of an agreement with the school, the genius with numbers could not patent his device.

At about the same time during the thirties, Konrad Zuse, a lone genius in Nazi dictator Adolf Hitler's Germany, offered to build a computer containing thousands of vacuum tubes to help the German military during World War II. The generals turned

AMAZING FACTS

George Boole (1815–1864) an English mathematician, could trace the way he thought clear back to Plato, the Greek philosopher. Their shared idea was that logic could be written mathematically. Boole, and Gottfried W. Leibnitz two hundred years before him, struggled over this concept, and it was Boole who shaped thinking about binary numbers. His use of 0 and 1 as on-off or yes-no concepts made today's computers work the way they do. Boole's mathematical ability gave his work its name: Boolean algebra.

the engineer down, telling Zuse that by the time the machine was finished, Germany would have the war against the U.S., Britain, and the Allies won! Nevertheless, the inventor created several programmable, automatic digital computers. Few people knew of this pioneering work until twenty years after the war.



John Atanasoff with his original computer. It was not until 1973 that a court gave Atanasoff the patent for the electronic digital computer. He never received any money for his invention.

Decoding Wartime Messages

Computers and warfare came together in Great Britain during World War II. The German enemy had invented a mechanical code machine, and the British were unable to decode its messages — until a defector reconstructed a similar machine for them. The German machine was called Enigma, meaning mystery. The portable device used two typewriters to code and decode secret messages. One typewriter received a message, scrambled it, and passed it to the second typewriter, which scrambled it further. When the war began in 1939, Enigma's messages became of incredible importance.

British scientists and mathematicians built a machine they called Colossus to decode Enigma's messages in the field. Colossus worked so well that British and American troops learned of German plans within minutes of the enemy sending its coded messages.

A successor to the machine that decoded Enigma helped the British find out about German plans to bomb the industrial city of Coventry. As the story goes, British Prime Minister Winston Churchill decided against warning the people of Coventry about the attack. He was afraid the Germans would realize their codes had been broken! A dozen decoding computers were in use by the British at the end of the war, many of them influenced by a British mathematician named Alan Turing.

Alan Turing (1912–1954)

Some inventors work with nuts and bolts and wires. Others work with nothing more than pencil and a notebook. Alan Turing, an English mathematician, scribbled a paper in 1936 that would virtually launch the computer age.

The son of parents who spent most of their time in India working for the British government, Turing was born just before World War I, in 1912. He was raised by a retired military couple in England, where he showed intense interest in science at a very early age. His foster parents rigged up a small laboratory for him in their basement.

During high school and then in college at Cambridge, teachers and fellow students remember Turing as untidy. With hair aimed in several directions and shirt not well buttoned, the young man excelled in chemistry, astronomy, radio, and mathematics. He also showed an interest in rowing and long-distance running.

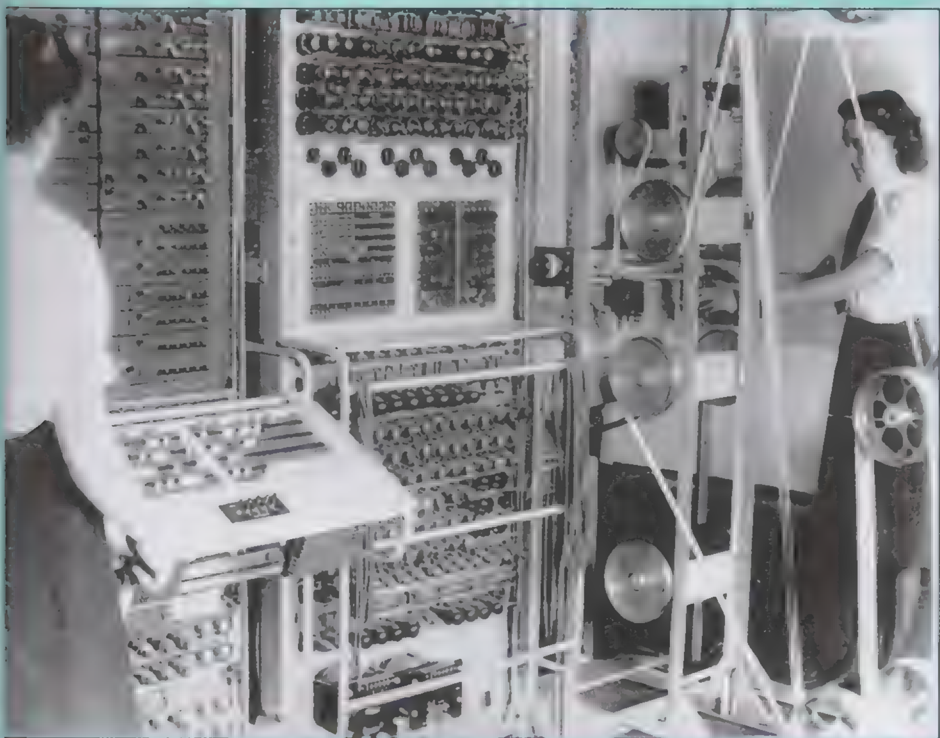
Turing was among the most bizarre geniuses ever, and the older he got, the more bizarre he became. He seldom shaved because the sight of even one drop of blood would cause him to faint. He sometimes wore a gas mask in public when his allergies acted up, and fellow students who tried to make conversation with him found his uncontrollable stammer and nervous laughter irritating.

Turing came to the United States in 1936 to study under John von Neumann and other mathematics professors at Princeton University. It was at Princeton that he wrote a paper, "On Computable Numbers," that set the stage for the numbers-based computing system we now use.

The Englishman imagined a keyboard connected to a machine that was fed information via tape. He also believed such a machine would scan the tape, accepting the information it wanted and erasing or changing the information it did not need. Mathematics genius John von Neumann invited the unkempt young doctoral student to be his assistant.

But war clouds were gathering over Europe, and Turing returned to England. There, he played a key role in unraveling the German code machine known as Enigma. He spent much of World War II in an ancient, rural house, working with fellow scientists to make and break enemy radio codes.

With the Allied victory assured, Turing began to build a computer. He wanted to prove with a computer that the paper he wrote in 1936 was correct. Another paper, completed in 1950, showed that Turing continued to be an incredible thinker. If it was impossible to tell from an answer whether that answer came from a human being or a computer, then it could be said that the computer was thinking, Turing said. He foresaw machines imitating human beings.



The British Colossus computer that decoded German messages during World War II.

The mathematician's brilliant career came to an early and tragic end in 1954 when the always-careless scientist ate an apple covered with cyanide. Apparently as he was using the poison as a pesticide while gardening, some must have accidentally gotten on the fruit. Just forty-two at his death, Alan Turing deprived the world of a mind filled with theories that time would prove correct.

The ENIAC computer with its inventors, John W. Mauchly and J. Presper Eckert, Jr., in the foreground. ENIAC had no memory to store the answers it obtained. It often broke down because the vacuum tubes it used were delicate, rather like electric light bulbs.

On the other side of the Atlantic, two men, John W. Mauchly and J. Presper Eckert, Jr., built a monstrous computer in Philadelphia, completing it in 1941. Weighing thirty tons and containing six thousand bulky electrical switches called vacuum tubes, the device was named ENIAC. Scientists joke that the first time ENIAC was turned on, it dimmed lights all over the city!

The public failed to note dimmed lights or much else about computers until they learned of physics professor Howard Aiken. He and others created the fifty-foot-long Mark I at Harvard University in 1944. Both ENIAC and the Mark I were used to improve the ways weapons worked during World War II.

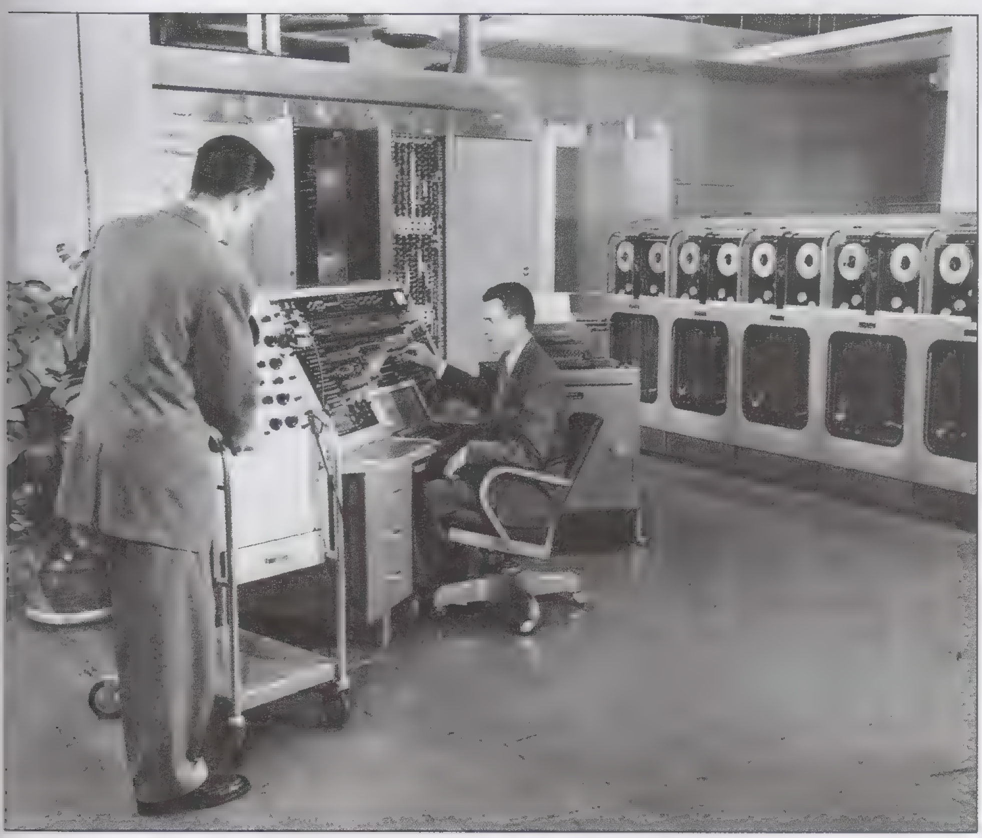
Postwar Computers

Work on computers continued in the late 1940s and early 1950s, a time when America was consumed with suspicions of the Soviet Union. Once the Soviets exploded an atomic weapon, U.S. military people believed their country should improve its air defenses against possible attack. These officers turned to a group of scientists and engineers from IBM and the Massachusetts Institute of Technology. These teams designed and built several computers that could identify approaching enemy aircraft and aim missiles at them.

The computer system had to be reliable so special vacuum tubes were created for it. These tubes were made out of new substances that gave off less heat and lasted thousands of times longer than the old tubes. Equally important, the computers

contained memories filled with information about friendly aircraft. When the computer's radar was pointed at an incoming plane and could not find friendly-aircraft characteristics about it, a missile could be fired at the aircraft! The system was set up in 1958 and, because of built-in quality, stayed ready into the 1980s.

Not all computers during the early postwar era were military systems. IBM, UNIVAC, and Control Data all sold wonderful, if large and hugely expensive, computers to the civilian government and to big businesses. These machines were given a tremendous boost by the government in a roundabout way. The bigger business and government got, the more numbers were needed. Businesses were required by the government to keep track of every worker's hours, what he or she was paid, how much Social Security and income tax was being withheld, etc. For tallying these and other figures, computers made the change from military to civilian use.



UNIVAC, or the Remington-Rand calculating machine, was typical of the sort of machine used by big businesses in the 1950s. Computer size was dictated by the bulky vacuum tubes that they used.

John von Neumann (1903–1957)

Born to wealthy Jewish parents in Budapest, Hungary, John von Neumann tried to apply mathematics to everyday life. No other American in the twentieth century, native-born or naturalized, was involved in so many different projects of real importance.

Long before Nazi Germany made Europe unsafe, von Neumann came to the United States. He arrived in 1930, having stunned European mathematicians in the 1920s with his abilities and lectured at Princeton University in New Jersey, becoming a citizen in 1938. No one, say friends, ever loved his adopted country more than von Neumann.

The workaholic mathematician was invited to Los Alamos, New Mexico, during World War II to work on the first atomic bomb. Von Neumann soon learned that a machine was being built that could make calculations faster than he could. He became entranced. Von Neumann went to the University of Pennsylvania, where the machine was being constructed, and saw the potential of the primitive ENIAC device.

ENIAC used vacuum tubes to speed its mathematical calculations. Von Neumann and others began working on an improved version, a computer that would possess the first stored, programmable memory. This so-called EDVAC would create both controversy and attention.

Was von Neumann the inventor of the stored-program computer? Or was it a lesser-known fellow scientist? (According to the United States Patent Office, the inventor was John Atanasoff, a professor at Iowa State University.) Regardless, the impatient mathematician's presence lent prestige to the project it might otherwise not have had.

Returning to Princeton after the war, von Neumann decided to put together what would be the world's fastest computer — a machine that could calculate scientific data in record time. Despite the complaints of his colleagues that he littered his office with clunky machinery, the math wizard invented the IAS computer in five years, finishing the project in 1951.

While working on theories about even better computers, von Neumann was appointed to the Atomic Energy Commission. He

became an expert on nuclear weapons, just as he had become well-versed in computers. His photographic memory could recall entire chapters of books or scientific reports, start to finish.

John von Neumann, right, with fellow scientist Robert Oppenheimer in 1954.

Von Neumann fell ill with cancer in 1954. Friends believed that he had contracted the disease as a result of exposure to numerous atomic tests in the New Mexico and Utah deserts. He died in Washington, D.C., on February 8, 1957. The country lost a great mathematician, an inventive genius, an atomic-weapons expert, and a patriotic citizen.

IBM Serves Business

IBM, the company that started after the success in counting th 1890 census, was the world's largest computer company by 194 By the early 1950s, it exceeded $100 million in sales each yea The company was run by Thomas J. Watson, Sr., a very com petitive man. Watson pressured IBM scientists to make faste and more reliable computers than the competition. The com pany became almost legendary, producing a series of computer called mainframes. A model created in 1964, the System/360 set the standard for computer products for U.S. business. IB became the best stock to own and America's most envied an respected company.

Computers were more and more commonplace in business a they became smaller, faster, and less expensive. IBM models ra on punched cards, and there were thousands of such cards to keep track of in any one business. A new job was created: keypunch operator. These people sat at machines similar to typewriters which converted information into holes in the cards. Keypunch positions resulted in thousands of jobs all across the country.

Besides keeping better track of payrolls, what else was done with computers? Many things, including more accurately fore-casting the ups and downs of a business. For example, a compa-ny manufacturing windows might receive reports of hurricane damage and feed that information into its computer. Along with other figures, it would tell the computer how many windows it nor-mally sold in the hurricane-hit area. The computer could foreca how many more windows had to be made — and what size — t satisfy the increased need created by the storm.

AMAZING FACTS

UNIVAC, the first nonmilitary computer used by business, was so large it would not fit in a two-car garage. Nor would it run if the temperature and humidity rose too high. And it was slow — an experienced abacus user probably could keep up with its calculations. Why, then, go to all the trouble? First, the device could run for hours, while a human could not. A correctly programmed UNIVAC might process information all night. Second, it printed results as it calculated them. And third, it did not complain about the coffee in the vending machines, ask for a raise, or leave the office before quitting time.

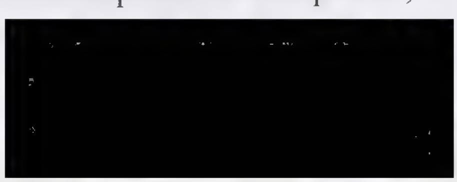
From Transistors to Integrated Circuits

Such automation became more available because transistor (smaller, more reliable electrical junctions) replaced vacuu tubes. The first transistor was created in 1947 in Bell Telephon

Laboratories in New Jersey by William Shockley and others. Transistors could perform a crucial on-off switch in a tiny fraction of a second. The Nobel Prize awarded to Shockley in 1956 indicated that the world knew the importance of the little devices. Shockley started his own company in Mountain View, California, the first firm in what would become known as Silicon Valley, home of the country's top computer hardware and software inventors. In 1957, Philco introduced the first commercially available transistorized computer.

The vacuum tube, left, and the transistor that replaced it in computers. Early transistors were one hundred times smaller than tubes, worked faster, used less electricity, and broke down less frequently.

Advances in technology made it possible to produce circuits containing many transistors, called integrated circuits. The first such circuit was put together by an electronics wizard named Jack Kilby at Texas Instruments in 1958. It allowed several electronic components to be placed in a single piece of semiconductor. In 1971, Intel introduced an integrated circuit containing a complete central processing unit, which makes all the decisions in a computer; it became known as the microprocessor or microchip. The concentration of so many transistors in a single chip has several advantages, including the ability to process information at a higher speed. A microchip the size of a penny may contain more than two hundred thousand transistors. Not only did its creation reduce the size, weight, and power consumption of computers, it reduced the cost.



An aerial view of Silicon Valley, California, showing computer factories in the foreground. It is the center of America's computer hardware and software production.

Talking to Computers

With each invention, more computers were sold and the average computer came closer to the life of the average person. Yet little progress would have been made had not several inventors, most of them mathematicians, figured how to "talk" to computers. Numerous languages were created that served as computer commands, but major breakthroughs in languages did not occur until shortly after World War II.

A number of people who had been active in the war effort now shifted their talents to civilian companies and produced brilliant languages that made computers do everything but stand on edge! Grace Murray Hopper was among the first to create what would become known as software, the programs that direct the computer's operations. After working on the Mark I computer at Harvard University, she wrote COBOL, a popular software business language used by hundreds of business computers, beginning in the 1950s. COBOL was a response to another computer language, FORTRAN. It had been created by John Backus at IBM for the scientific community, and Grace Hopper realized there were additional software needs.

So did two Dartmouth College professors, John Kemeny and Thomas Kurtz. They came up with a wonderful idea:

computers should be available for use by college students and other ordinary people. They knew that the complexities of COBOL and FORTRAN scared off most computer enthusiasts, so they talked employees of a General Electric office in Massachusetts into letting them use a company computer to write a new software language. Kemeny and Kurtz created BASIC, a much easier language that they tested successfully on college kids in 1964. Dartmouth copyrighted the language and offered it free to whomever wanted to use it. It quickly became the most popular computer language.

A modern integrated circuit in the eye of a threaded needle. The earliest chips from the 1960s contained about fifteen transistors. Today, they can contain millions.

Meanwhile, Digital Equipment Corporation, a small firm in Massachusetts, took advantage of microchips to produce the first minicomputer. Digital was founded by a scientist named Kenneth Olsen who had picked up plenty of computer experience while at the Massachusetts Institute of Technology. He and others worked seven years to create their small unit. "Small" at that time meant a price tag of $27,000, still some distance from what we know today as the cost of a truly personal computer. At least, the Digital computer was convenient — it could be upgraded and it was easy to use.

Could a personal computer, lightweight, inexpensive, easily used, and sitting in a home office, be just around the corner? The answer would be a resounding "Yes!"

Grace Murray Hopper (1906–1992)

Before Grace Murray Hopper, only mathematicians could talk to computers. The granddaughter of a U.S. Navy admiral and a civil engineer, Hopper was born in New York City and showed an early interest in mechanical things. On a summer vacation as a child, she took apart and put back together seven different alarm clocks!

Hopper studied mathematics, physics, and engineering at Vassar College, one of the few women's schools in the country during the 1920s that offered girls advanced mathematics and science. She followed college graduation with a master's degree and a doctorate, both from Yale University, in math and physics. Hopper taught at several colleges before going on active duty with the U.S. Naval Reserve during World War II.

Given the rank of lieutenant because of her education and experience, Hopper was assigned to a ship computation project. And what a project: Harvard University and International Business Machines (IBM) had put together a magnificent "computing engine." The trouble was, few people could make it work. Grace Murray Hopper realized quickly that her years of education and training were all aimed at getting this machine, the Mark I, to run at its full potential.

Grace Hopper working with a computer during World War II.

American weapons needed rapid information, and the Mark I could do three additions a second. To apply such figuring to laying a mine field or aiming a big gun, Hopper wrote a book that told how the computer worked. It was called *The Manual of Operations for the Automatic Sequence Controlled Calculator,* and it was as good as its title was long.

Hopper shepherded the computer for months, writing programs and solving problems. Following the war, she worked on bigger and better versions of the computer. She

joined a company on the verge of creating another working computer named UNIVAC I, quickly inventing a numerical code that told the machine how to perform.

Hopper was a perfectionist who was dissatisfied with the many mistakes most computer codes seemed to have in them. So she sat down and created an entire language for the UNIVAC, working on it well into the 1950s. This language would eventually be called COBOL and would become America's most widely used business computer language.

Rear Admiral Hopper at her retirement ceremony aboard the USS *Constitution.*

COBOL stood for Common Business-Oriented Language, and it allowed offices to work at the same exacting standards as military personnel or scientists. The language, once learned, brought real efficiency to the workplace. It also brought fame and a new title to Grace Hopper: In 1964, she was named staff scientist with the UNIVAC division of Sperry Corporation. More important, the Navy asked her, at the age of sixty, to rejoin. So she was inducted in 1967 and spent eighteen more years in the military, thanks to a special act of Congress.

Despite her longtime love affair with computers, the small, aging woman was never afraid to criticize the industry. There were no standards, there were too many people who thought big computers were always better than small ones, and there was too much emphasis on quantity, rather than quality, of information.

Feisty as always, the woman who was turned down for active duty at the age of forty for being too old retired from the military in 1985. She was soon hired to work for Digital Equipment Corporation (DEC), a major computer maker. Her mind remained active until a fatal heart attack in her home on January 1, 1992, at the age of eighty-five.

Chapter 3
Computers Everywhere!

Once inventors figured out that many transistors and their connections could be etched on a piece of silicon, computers began to shrink in size. The silicon was a fingernail-sized computer processor unit that was able to do more than entire sections of big computers of only a few years earlier. While Intel began to sell these first microprocessors or "computers on a chip" in 1971, firms such as Motorola and Rockwell soon began manufacturing their own chips. The first use for these microchips was in Japanese-made hand-held calculators.

Computers became commonplace, but the first personal computer was still several years away. Where, besides calculators,

A video game simulates Formula 1 motor-racing conditions. The force felt on the game's steering wheel is designed to be just like the real thing.

were the microchips showing up? The tiny bits were running video games, introduced in 1972 with electronic ping-pong. Pong, as the Atari ping-pong game was called, initially was a coin-operated game. But by 1974, it was on toy store shelves and was followed by Pac Man and dozens of other popular games. The video game industry would grow to be a $5 billion-a-year business. Although video games had limits, they were the first in-home computers for millions of Americans.

Personal Computers Come Home

A small firm introduced the Altair computer in 1975, marking the beginning of the personal computer age. Quickly overshadowing the Altair was the Apple II, created by two guys named Steve — Jobs and Wozniak. The Apple II was the first reliable personal computer. Jobs and Wozniak had used quality materials and made the computer and keyboard all one unit. With a TV monitor sitting atop it, it was lighter and looked more like something for a home desk than did most of the competition. The ultimate compliment paid to the Apple II is that it sold in the millions and was offered by Apple retailers until early 1994!

Mighty IBM entered the home computer market in 1981. The PC, as it was called, quickly gained acceptance in the home, though as late as 1983, Commodore, Atari, Warner Communications, Tandy, and Timex all outsold it. One of the real meteors of the business was Osborne, which sold $100 million in dependable, lightweight computers one year, 1983, and was bankrupt the next. Osborne was unable to use IBM-compatible programs and failed in part for that reason. Texas Instruments got out of the home computer business at about the same time, while once-great Commodore hung on a few years more.

Also in 1983, IBM offered the XT, an improved version of its PC, and Apple brought out the Lisa. The XT offered a greater ability to store information, since it had nine times the capacity of the original PC of only two years earlier. The Lisa failed to

A modern Apple Macintosh computer. The price of home computers continues to drop dramatically even as machines become more powerful.

attract its share of buyers because of its hig price, but it set the stage for the Macintosh.

The $10,000 Lisa is best remembered a the first computer with a mouse. The hand controlled electronic pointer slid along a pa and made an arrow move around the Lisa' screen. Rather than learn a computer lan guage or a bunch of nonsensical letters an numbers to operate the computer, all you ha to do with the mouse was point it toward a word on the screen and click its button. I the word were "Save," for example, whateve you had been working on would be kept in a file, just like in an office, ready to be pulled out and looked a again. A mouse is common today with all kinds of computers.

Better, Cheaper Software

Microcomputers for home use such as the XT and Apple's new IIe sold for as little as $1,000. More sophisticated micros carried price tags of as much as $30,000 for complex machines used by engi- neers. Some 2.8 million computers were sold in 1982, making the total home computer market worth $4.9 billion. As prices of hard- ware went down, so did prices of software. Wonderful tools such as a budgeting program called VisiCalc turned everyday business people into predictors of their companies' futures. Called a spreadsheet because numbers could be spread across many columns, VisiCalc was introduced in 1979 and sold for only $150.

Equally handy, if more expensive, was Aldus PageMaker. Before PageMaker, artists, printers, and graphic designers labored long and hard over the way newspaper, magazine, or book pages read and looked. PageMaker allowed them to pro- duce pages that were "camera ready" — meaning that no further work had to be done on them before they could be fastened to presses and printed. As magazine budgets tightened, PageMaker

and similar desktop publishing (DTP) programs saved dozens of publications by cutting preprinting costs dramatically.

Word processing remains the most common use of the home computer. Two word-processing programs, Microsoft Word and WordPerfect, have nudged aside many other brands. Each carries a number after it — the higher the number, the more modern the version. WordPerfect 5.2, for example, is older than WordPerfect 6.0. Work created on older versions of programs usually can be transferred to the newer versions with no problem.

Many kinds of jobs and services were computerized in the early 1980s. The Official Airlines Guide demonstrated a computerized version of its worldwide service. For a small fee, clients with computer terminals were able to check schedules, routes, and prices, though it was not until later that subscribers could make reservations and write their own tickets. During the eighties, people became accustomed to reserving rental cars, ordering flowers, sending gifts, seeking information, and more, all from their offices during the day or from their dens at night.

As well as aiding in typesetting and graphic design in publishing, computers are widely used in the printing industry. Here, color separation is achieved using electronic scanning equipment. The original artwork can be seen wrapped around the scanner's drum.

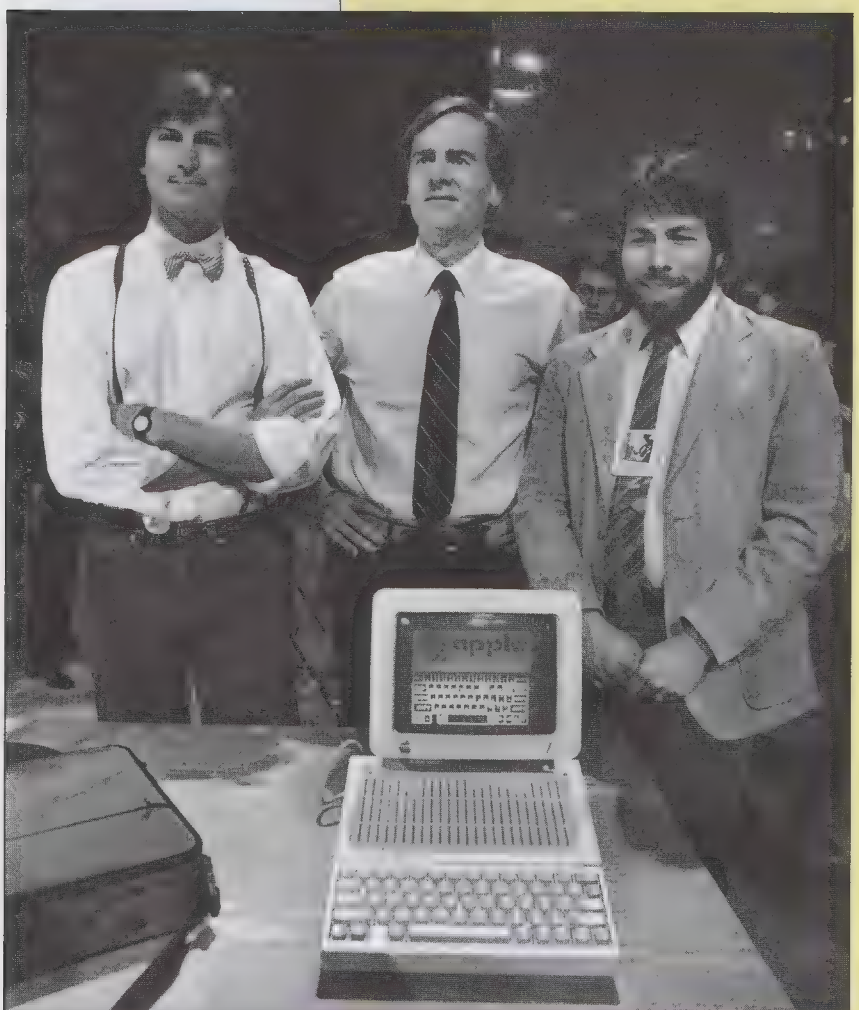
Steve Jobs

Steve Jobs's background doesn't read like the American Dream. An orphan, he was a mediocre student and a college dropout who briefly dabbled in drugs and in obscure Eastern religions. How did such a person become worth as much as $450 million?

Jobs earned every cent by being in the right place at the right time and by knowing what the public wanted — long before the public ever sat at a computer keyboard. Luckily, he grew up in Los Altos, California, the heart of America's computer industry. During a school tour of a Hewlett-Packard factory, he saw a small computer and immediately wanted one. Barely a teenager, Steven got a summer job screwing together small parts at the Hewlett-Packard plant.

Jobs met Steve Wozniak, an older boy who loved tinkering with electronic gadgets. Both were interested in technology for recreational purposes, but there the two parted company. Wozniak was skilled at electronics while Jobs was good at marketing. Jobs went to college for a semester before dropping out to work for a new computer game company called Atari. He took a leave of absence, traveled the world, and returned to northern California.

Steve Wozniak had started a computer club during Jobs's absence, and the two Steves put together a homemade computer they named Apple I. Unlike most computers at the time, it was easy to use and



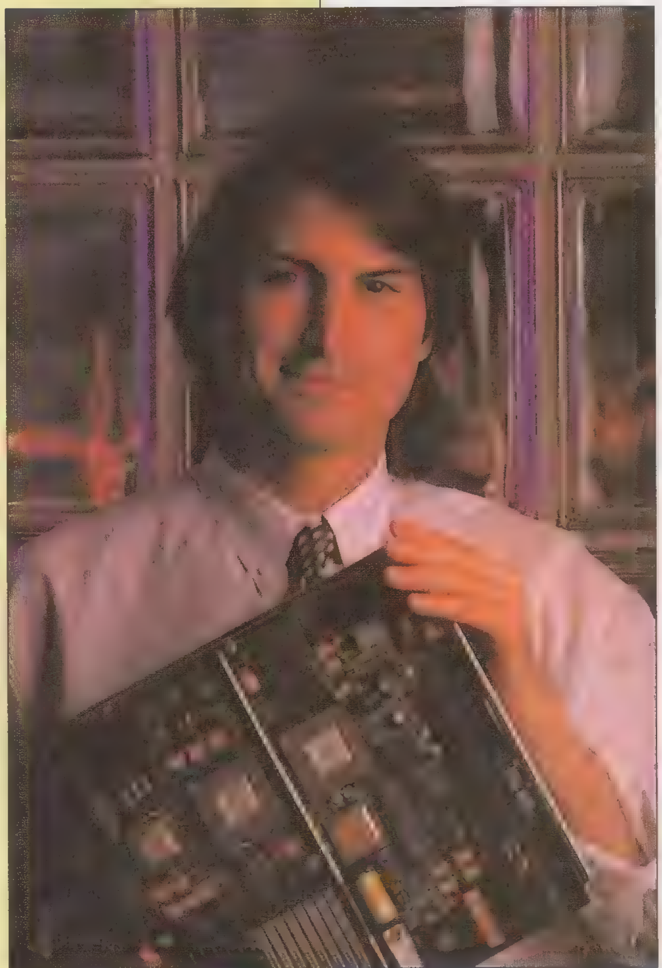
Steve Jobs, left, Apple president John Sculley, center, and Steve Wozniak unveil a new personal computer in 1984.

much more reliable than higher-priced models. By 1976, Apple Is were selling like crazy. Investment poured in, and Wozniak quit his full-time job with Hewlett-Packard to join Apple Computer. A new product would soon put the small firm on the map.

Wozniak and others created a twelve-pound home computer that sold for $1,350 and was constructed so that home computer buffs could add to it. It could create documents, play games, balance checkbooks, store recipes, show flashy graphics, connect with a modem, and more.

Sales zoomed. The company reached $117 million in 1980, $985 million in 1983, and more than a billion dollars by 1985. Jobs's stock in the firm became worth $165 million within months and climbed from there. Wozniak owned half as much as Jobs.

But the Apple founders weren't content, particularly since their rivals, IBM, also introduced a popular personal computer in 1981. So the company created the Macintosh, with its mouse pointer, a computer with a great deal of memory that could be operated a few minutes after opening the box. In 1986 alone, some six hundred thousand Macs were purchased by everyone from architects to zookeepers.



Steve Jobs holding a circuit board at NeXT, the computer company he owns.

Jobs became impatient with Apple management and left the company to begin work on a computer he called NeXT. This unit would allow researchers to perform calculations previously done only with huge, mainframe units. Despite investment from wealthy backer Ross Perot and others, NeXT failed to achieve all Jobs had hoped.

The Apple founder, who turned forty years of age in 1995, remains a wealthy and respected man. He has purchased Pixar, the computer graphics division of Lucasfilm, maker of the Star Wars film series. Computer and entertainment people alike are wondering what spectacular things Steven Jobs will do in the future.

Computer-aided design (CAD) packages can be used to choose the best layout for a retail goods display without using real products. Printouts of the design can then be distributed to all the stores in a chain. Processes like this can save companies a lot of time and money.

Going On Line

CompuServe, followed by Internet, Prodigy, and other services, soon allowed Americans to do all sorts of things with their home computers. They are part of the information highway. Computer owners use modems and telephones to connect to these huge computer banks. Once connected or "on line," users can argue politics, look up encyclopedia facts from a huge pool of knowledge called a database, leave notes for fellow hobbyists — or fall in love. Some people with access to the information highway find romance, while others get religion! Ecunet, for example, is used by pastors and others interested in religious views. There are networks for Jews, evangelicals, and more. Knowledge, friendship, romance, religion, and more are just a phone call away.

AMAZING FACTS

The information highway can be an expensive way to travel. A Neenah, Wisconsin, teenager ran up a bill of $600 in one month as he chose expensive options on Prodigy. The youth shrugged off screen messages that warned of extra charges because he was having so much fun with his computer.

Internet connects people in 137 countries to one of 1.7 million central computers. Until recently, users were scientists, teachers, and students. But general use is soaring. Users send inquiries from their computers through modems (which connect computers to phone lines) to a bank of receiving modems. This bank connects the user to the Internet service. Requests travel to

the desired computer, where the needed information is stored. Most requests go through at least one in-between computer before the right request meets the right computer.

It was first thought that the Internet would provide people with incredible amounts of information and, with its ability to send messages from anyone with a computer and modem to anyone else in the world similarly equipped (through e-mail), increase the sense that the world had become a global village. However, surveys in 1994 showed that there are fewer than ten million people on the "Net," far less than the thirty million first estimated. About half of them never use their connections to the information highway for anything more than receiving personal messages. Will access to this vast pool of information be untapped and all these computer services be used by only a relatively few researchers? We'll only be able to judge by the computer users growing up today.

A woman paralyzed in both legs attempts to walk with computer-driven walking aids strapped to her legs. Disabled people can improve their lives in many ways with computer-controlled devices.

From the Home to the Hospital

Outside the home, computers are used in a vast variety of ways. Internet and other databases are of great use to physicians, who can call up information on various diseases. Whereas a rural physician might spend a minute or two a day in front of a computer, a surgeon in a large teaching hospital might use a computer 85 percent of the time, calling on fifty different computers in a typical day. These computers make diagnosis and therapy more accurate because they have a great deal of information immediately available, not only about the individual patient but about the disease or problem the patient may have. Many specialists benefit from computer use, but those working where seconds count, such as in

emergency care or cardiology, find them to be lifesaving devices. Computers also monitor vital signs in intensive care units.

As you saw in chapter 1, computers are invaluable in diagnostic imaging. They receive raw data from the picture of the patient's afflicted organ or limb and reconstruct the image mathematically. This is done with computerized tomography (CT) or magnetic resonance imaging (MRI). CT devices are most valuable where x-rays don't do a very good job, such as within the skull. CT views can be enhanced by the use of contrast agents — chemicals introduced into the bloodstream that make the image much clearer. MRI equipment uses magnetic properties of atoms to produce an image. It processes the data, reconstructs and displays the image, and stores the information for future use.

What do the heart pacemaker, artificial heart, artificial ear, biofeedback devices, and artificial arms and legs have in common? They're all microprocessor-controlled devices. Other computer-controlled devices include the respirator, which helps a patient breath, and the hemodialyser, which performs the function of the kidneys by cleansing a patient's blood of impurities.

Doctors can study anatomy using a virtual reality system. The image of the human leg they can see and feel is in the middle of the picture. Their headsets contain 3-D (three-dimensional) video displays of computer-generated images. Their gloves contain optical fiber sensors that relay their movements back to the computer.

Computers are, of course, also used as teaching tools. Their ability to portray organs at work or show the details of a fracture make them as necessary as any lecture. Self-instruction, where the medical professional is guided through a learning sequence at a pace he or she controls, also is popular. And physicians call on databases all the time in informing patients of their chances of success in surgery and other procedures. Databases are also used to manage patient records and to send a bill promptly.

Computerized Robots

Computers can also help protect human beings from possible illnesses as well as help doctors in healing individuals. Computer-run robots can be used wherever a work environment or task gets too hazardous, annoying, or confining for humans. They're frequently used on assembly lines, where the repetitive motions would cause stress injuries for workers. Robots are often steel- or aluminum-framed devices of modest size that weld, spray paint, or otherwise produce material. Robots work most efficiently making the same simple, repetitive passes with a welding gun all day long. Their on-board computers run disks with programs that transmit various series of movements.

That's not to say that all robots act, well, robotically. The Franklin Institute in Philadelphia recently began showing several larger-than-life, computer-controlled insects that are robots. The huge creatures were completed after engineers studied how the various bugs moved. The display includes carpenter ants, a scorpion, a black widow spider, a praying mantis, a unicorn beetle, and a dragonfly. Beneath the plastic and fiberglass frameworks are hydraulic parts that are programmed to move realistically.

Computerized robots have entered volcanoes, descending down the fiery lip to temperatures no human could stand. They've also been used in space to perform numerous experiments onboard rockets. In the future, they may enter other hostile environments and "boldly go where no one has gone before."

AMAZING FACTS

Several years ago, a robot killed a Japanese worker. The programmed robot moved through its cycle, and the unsuspecting employee got in the way and was crushed. Since then, precautions have eliminated most such dangers. A common safety device in the United States involves a simple electronic mat placed in a circle around an operating robot. Whenever anyone steps on the mat, power to the robot immediately shuts off.

Chapter 4
Today's Computers

Modern computers can do five things: They can receive information, they can store information, they can manage information, they can use the information to solve problems, and they can produce the information for the operator to use.

Computers receive information from a person typing on a keyboard, from disks, tapes, compact disks (CDs), or from other computers. The information they receive is stored on disks, tapes, compact disks, or drums. Any information stored in the computer can be used by the computer to make decisions. It can do this because it runs on a program, a set of instructions created, at least originally, by a human being.

AMAZING FACTS

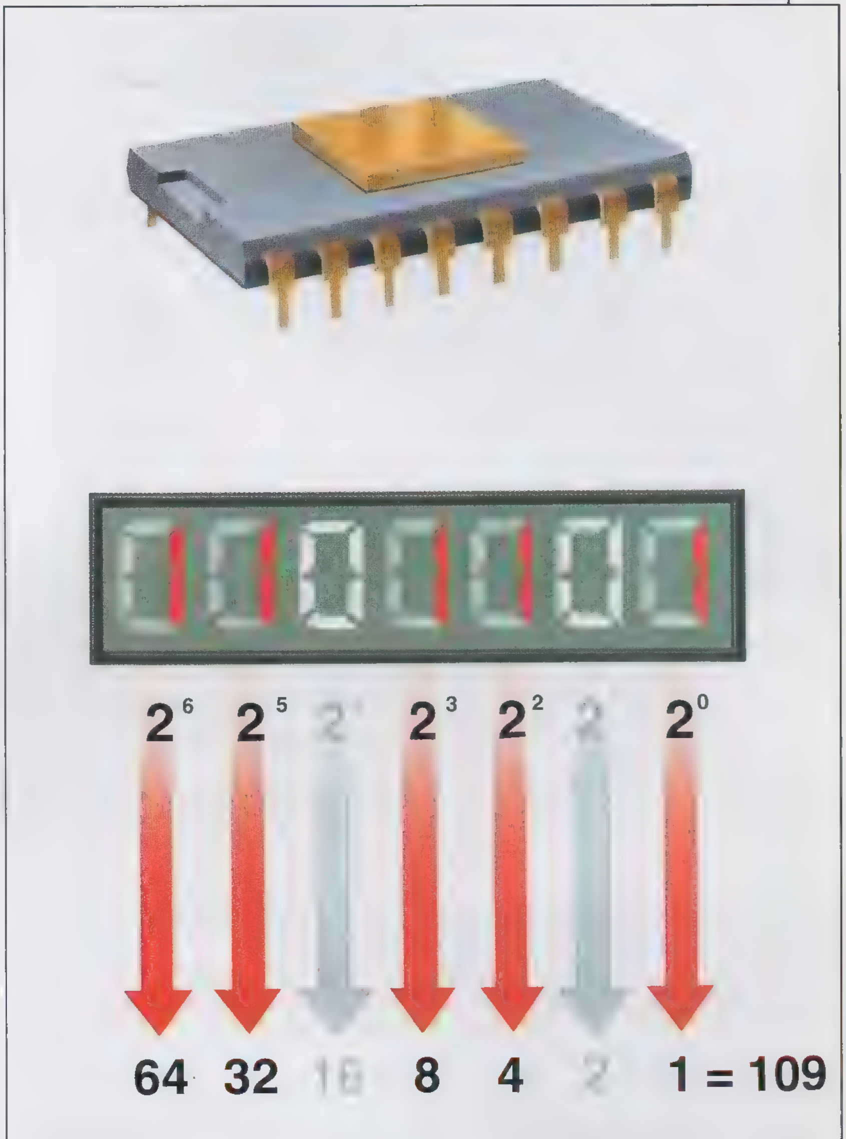
William Gates, inventor of the Microsoft Disc Operating System (MS-DOS) became a billionaire in 1987, at the age of thirty-two. Today, the Seattle native is among America's richest individuals.

Every working computer has a program. The program is created by computer experts with lots of experience and training, but every program is as simple as "on" or "off." That's because it is binary, that is, based on two parts. All computers run with the assistance of programs made up of the binary numbers, *0* and *1*, which mean "on" or "off." By using complex techniques, *0* and *1* can be made to represent various numbers, letters, symbols, codes, or program instructions.

The heart of a computer is a central processing unit, called a CPU, which uses the binary system. Grouped around this CPU are several devices that help it operate at split-second speed. The electronic circuitry either is told by a program to conduct or not conduct electricity. This process, which takes place in an instant, is the basis for all modern, digital (number-based) computers.

Can computers be asked questions other than those involving *0* or *1*, and can they leap past the on-or-off sequences to find the

ht answer? It almost seems Apple Computers sells a mputer that "reads" the ner's handwritten notes on a ecial pad, then prints those es in type. How can the mputer "recognize" hand-iting and convert it to individ- letters? By converting the coming information to binary de — strings of *0*s and *1*s. — hich is then interpreted by the mputer. It's programmed to erform rapidly in this way, eciding in less than the wink of eye if the loop you wrote is a wer-case *l* or a lower-case *t* you rgot to cross!



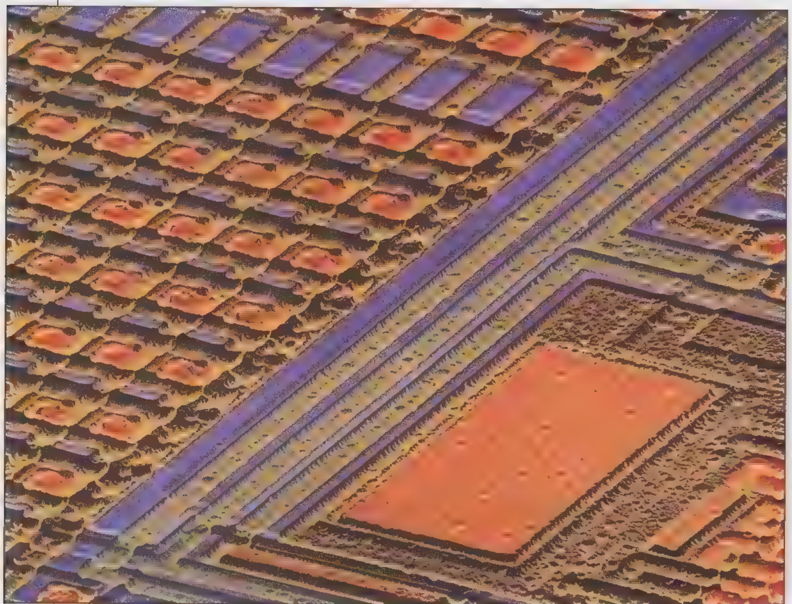
Computers do their calculations using the binary system, in which each column going left has twice the value of the previous one. Because the system only uses the figures one and zero, any number can be expressed by on or off electrical currents.

A Quicker Connection

Originally, this kind of work was one by many vacuum tubes. acuum tubes resemble small ght bulbs and can be found oday inside old radios and tele-sion sets. But the vacuum tube was too slow, and it was replaced y the smaller, faster transistor, which could open or close circuits n a millionth of a second.

The use of transistors, which have three terminals or electrical onnections, greatly reduced the size and improved the efficiency f computers. Originally made of germanium, transistors were made with the more stable silicon after 1960.

Today, integrated circuits contain many transistors on the ame chip. These integrated circuits permit the formation of



The etched surface of part of a silicon chip magnified 300 times. The tracks that form the chip's circuitry can be seen. At the left are rows of memory cells.

complex electronic circuits that carry out complete functions.

A form of integrated circuit, microchips as they are called, helped further shrink computers. The very first computers took up large rooms and were sensitive to changes in temperature. Big companies had special rooms for their 1950s computers, where operators moved around whirling spools of paper tape. Temperature and humidity were controlled. The chip, introduced in 1971, allowed computers with incredible power to be shrunk to a size that they would fit on a student's desk — with room to spare.

Today's home computer is faster and more powerful than the cumbersome devices bought for hundreds of thousands of dollars by banks and insurance companies a few decades earlier. They also use much less electricity and are easier to use. Computers in the 1950s and 1960s could only be operated after the user learned a new language. This could be COBOL or FORTRAN or other sets of commands never spoken by human beings but necessary to make computers perform. BASIC, a common computer language today, uses common-sense commands, while other computers merely wait for the operator to make one or more keystrokes or point a small arrow at the right word and hit a button.

Buying a Computer

Once a person decides to buy a home computer, there are two choices — an Apple Macintosh or an IBM-compatible, which may carry the IBM brand or any of several other brands. Macs, as Apples are known, are easier to use, but there is more software for IBM-compatibles, which are also known as PCs.

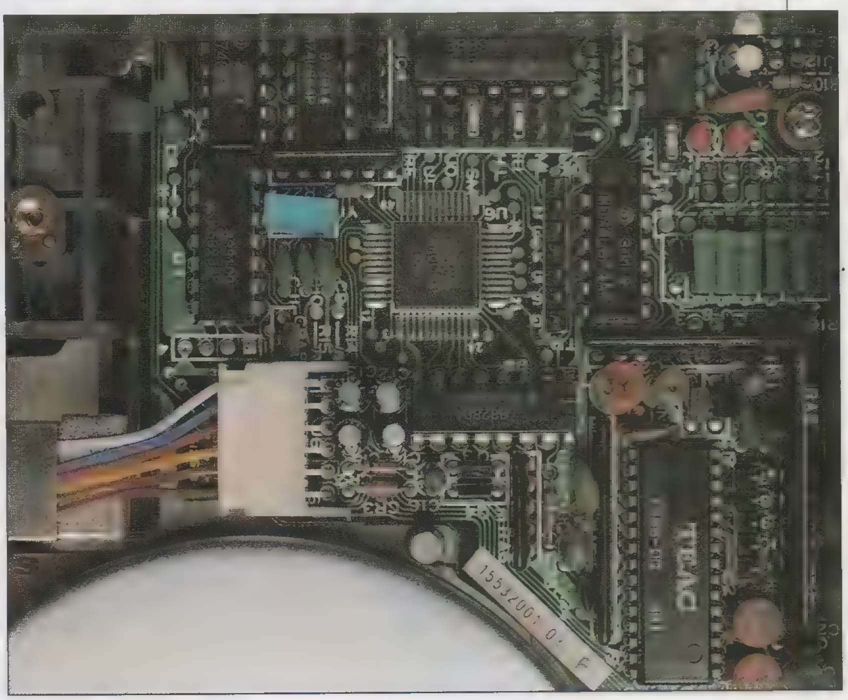
All PCs work the same and run the same software. Some have more capacity than others, which means they can hold more programs and perform more work simultaneously.

Another consideration is the kind of microchip inside the computer. The faster the chip, the faster the computer will work. The fastest IBM-compatible chip is called a Pentium. It is used in multimedia work, which can include sound, video, animation, and text. It takes a computer with a large memory for the Pentium chip to perform best.

The computer's permanent memory is called a hard drive. The bigger the hard drive, or memory, the more programs and files the computer can offer. People interested in a PC probably will use software written for the Windows operating system. Windows files need a computer with a hard drive that offers plenty of memory.

The only company that makes Macintosh machines is Apple. Well, that's no longer completely true. Apple recently announced that it will let other manufacturers make computers similar to the Macintosh but only for foreign markets. That doesn't help much!

The interior of a floppy disk unit. Most modern home computers have both hard and floppy disk drives, so information stored in the computer memory or on the hard disk can be copied to floppy disks and used in a different computer.



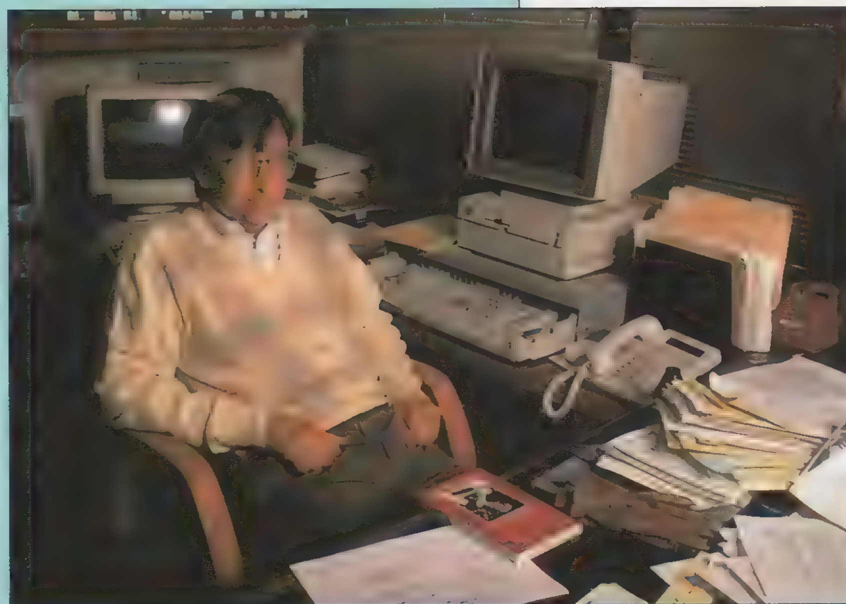
There are several different Macintosh models, and like the PCs, there is more than one microprocessing chip. In this case, it's a choice of the 040 chip or the more powerful Power PC chip. The Power PC is a real breakthrough in that it can run either Apple or PC software. The faster chips are more expensive, but they will perform more functions for a longer time before the computer is out of date. Fortunately, newer Macintosh models with the less expensive chip can be upgraded.

William Gates

Not many computer whizzes appear in *People* magazine. But then, not many are worth more than a billion dollars. William Gates, head of Microsoft, commands attention because he has so much and seems to want so much more.

Gates was born of well-to-do parents in 1955 in Seattle. Attending a private school, he earned $2,400 as a ninth-grade student by using rented computer time to create the school's class schedules. The lanky youngster with glasses and a mop of brown hair soon was making thousands working for software developers. He entered Harvard University in Massachusetts in 1973.

Bill Gates's life would change after he read the January 1975 issue of *Popular Electronics*. The magazine told about a small Altair computer, made in New Mexico, that sold for $350. Gates saw that



the door was opening for makers of software for personal computers. He and a friend left school; otherwise, he said, "the revolution would have happened without us."

Gates and friend Paul Allen moved to Albuquerque and began writing computer software. They soon learned that people were pirating their hard work, and Gates came to the realization that software programmers such as himself should be paid for their talent. Gates and Allen founded a corporation they named Microsoft, indicating that it made software for computers using microchips, and moved the business to the state of Washington in 1978.

IBM approached Microsoft when the computer giant was building a personal computer and needed software to run it. Gates became an IBM consultant. Working feverishly, he introduced the Microsoft Disk Operating System, or MS-DOS, in March 1981. IBM personal computers were a huge success, and Gates began to receive more money than he could count — except with a computer.

But Microsoft's directors were not satisfied. Many other software programs were created, including Microsoft Word, the program with which this book is written. Bill Gates, still young and fiercely competitive, directs work on other projects. He envisions putting together software that will connect every conceivable device — telephones, facsimile machines, modems, television sets, and more — for the world's millions of users. The company also is involved in compact disk (CD) technology.

Gates seldom takes vacations, and he keeps his staff young: the average age of Microsoft employees is about thirty. The company Gates founded is so successful that a business magazine recently suggested Microsoft be broken up into smaller companies to give its competitors a fighting chance.

AMAZING FACTS

What's the most often-seen symbol of a computer these days? It may be the bar code on most consumer products. This small series of lines is scanned to tell price, to tell the computer to reorder, and to tell the stock clerk to move more of the sold items from storage to shelf. Bar codes are even used by railroads: As cars pass certain points, the bar codes on their doors are read and transmitted to a central computer. A customer awaiting the car full of freight can learn the car's location and when it will roll into town.

Most computers are sold as packages. In other words, the system comes with a keyboard and a monitor, most often a color one. The best monitors are those with very little space between picture dots; this is known as a high dot pitch. There is more difference among PC monitors than among monitors for the Mac.

Not many years ago, dot-matrix printers, which created letters made up of many small dots, were standard. They have disappeared due to the high quality and low prices of laser printers. Lasers use the same kind of technology as copying machines to create images. Another alternative is an inkjet printer, which sprays the blank page with words and images. Printer prices depend on quality and whether you want color or black and white.

An Array of Programs

No matter what kind of computer chosen, there are hundreds of programs for it, with new ones being offered all the time. Like the hardware, software continues to decrease in price as capabilities increase. A typical modern program is Quicken, available either for Macintosh or IBM-compatible computers.

Quicken is one of many home-finance programs that helps computer users manage their money. You can tell Quicken how much you've earned and spent, and Quicken tells you if you can afford a new car or to send a child to college. It helps budget, it simplifies getting taxes ready, and it will balance a checkbook. All Quicken takes is a minute or two each day for entry of money taken in and money going out. About six million Quicken programs have been sold.

Useful Accessories

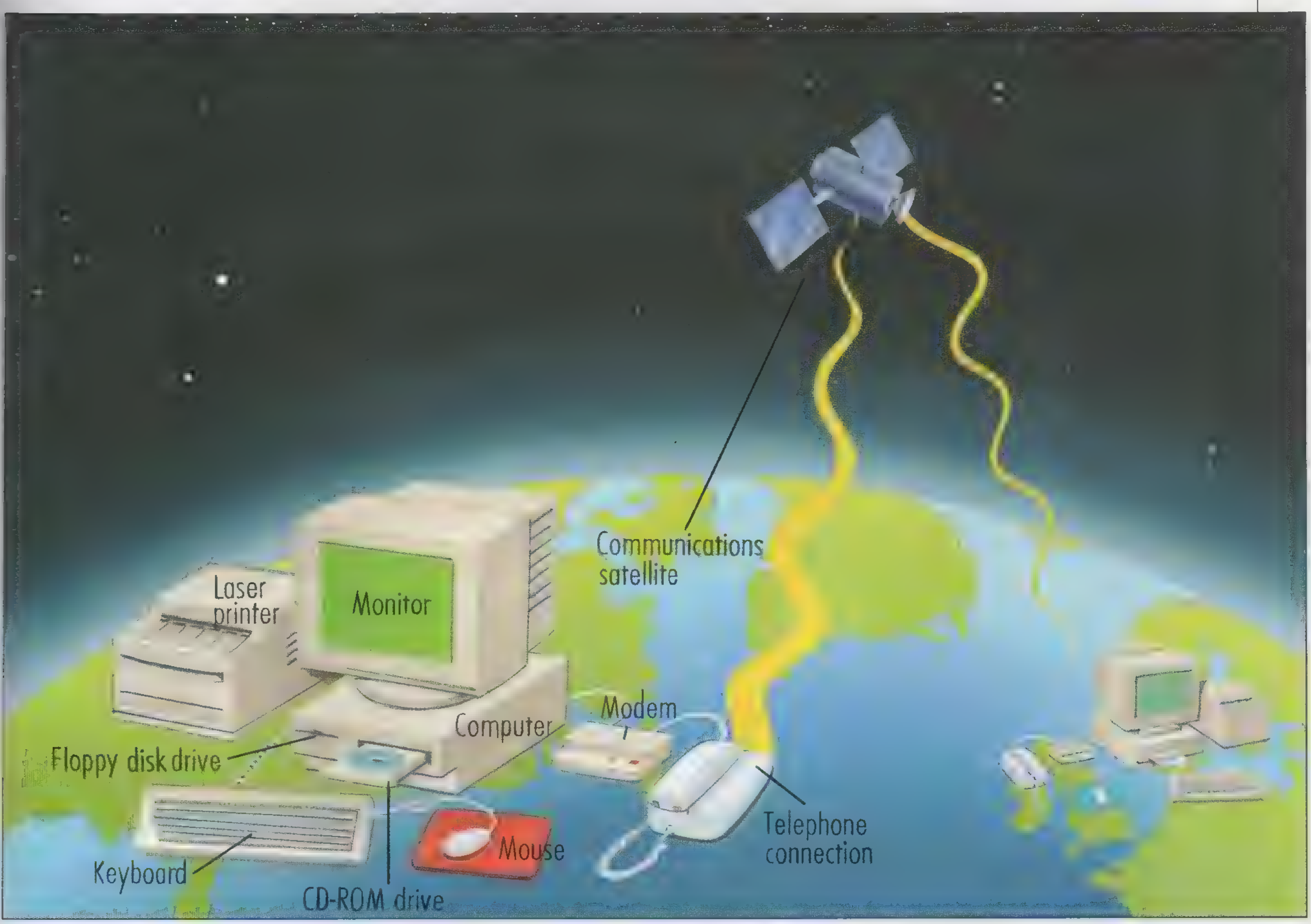
There are other exciting items besides programs for computers, most of them recently invented. They include:

- CD-ROM. The CD-ROM is a compact disc that contains information instead of music. ROM stands for "read-only

memory," which means you can read or copy the information on the disc, but you can't change it. After, all, you wouldn't want to change statistics on a CD containing the encyclopedia, would you? Many computers are available either with external or internal CD players. Inventors have also created very realistic games on CDs.

- Multimedia (sound, sight, and printed information) software. If you're studying Abraham Lincoln and you call up this famous president, you may get a scroll of the Gettysburg Address and a portrait. If you click on Lincoln's portrait, an animated feature of Lincoln delivering his famous speech might begin! The bottom of the screen could include related topics, such as the Lincoln-Douglas debates, the

Today, computers can communicate with each other across the world via the telephone network. You need a modem to link your computer to your phone. Then you can send messages to anyone else whose computer is linked to an electronic-mail network. You can also pay to access giant computer banks or you can join smaller networks that specialize in subjects you are interested in.



AMAZING FACTS

In 1983, Texas Instruments introduced a personal computer that would obey voice commands. The basic model cost less than a similarly equipped IBM PC that could not respond to the human voice. Perhaps surprisingly, the device did not sell well, and the company quit the home computer business later that year.

Emancipation Proclamation, or a digest of Lincoln's most famous sayings. What a way to learn history!

- Modems. You can't go for a ride on the information highway (a network linking computers) without a modem. These devices connect an individual's computer through the telephone to Internet or CompuServe or other information networks. There are bulletin boards, discussion groups, help-wanted ads, lonely-hearts notices, and more. Because they are versatile and popular, information networks have been abused by hate groups, fly-by-night salespeople, and other exploiters.
- Finally, don't forget the mouse! That's the little device, about the size of a fist, that lets the user scoot arrows around on the screen, clicking on commands and making programs appear and disappear in a flash.

There are still other uses for home computers. At Dartmouth College in New Hampshire, for example, students no longer feel guilty about failing to write letters to their families. Now, they can keyboard messages to their homes through school computers, using a national electronic-mail network. Parents with a computer and a modem will receive messages from their children and can send messages back. Students check for messages whenever they pass a school computer.

In school or out, would-be inventors have developed their computer interest on used machines. Computers can become obsolete overnight, and the price of a new one plummets the minute it's purchased. Many of tomorrow's inventors will learn on yesterday's machines.

Computers can aid teaching and also be a substitute for practical work. Here, a science teacher shows students a cross section of the digestive system of a frog, making it unecessary to dissect a real animal.

Chapter 5
Hackers and Other Woes

Computers have been used for an incredible variety of tasks. They have improved a home movie that showed the assassination of John F. Kennedy, and they have been used to study the Shroud of Turin, a cloth that may have covered the body of Christ. Unfortunately, computers also have been used for less noble activities.

Robert Tappan Morris, Jr., was a student at Cornell University in Ithaca, New York. The young man knew all about computers and that was his undoing. In November 1988, he created a "virus" that shut down a nationwide computer network. A computer virus is a piece of software that ruins other software. Morris used a computer and a modem to send his virus through telephone lines. He caused damage to government and private computer centers that resulted in confusion and work to get things operating correctly. The student was fined $10,000, placed on probation for three years, and ordered to perform four hundred hours of community service.

Morris could be considered a hacker. Hackers are usually young, talented people who play with computers for hours on end. They know a lot about software and realize that, by using just a computer and a telephone, they are able to get inside distant computer systems that may contain secret or private information. Hackers have found ways to change medical records, alter payrolls, read military intelligence, and conduct other illegal and dangerous activities. A West Coast hacker even managed to pull the largest bank robbery in U.S. history. He did it armed only with a telephone!

AMAZING FACTS

Part of the blame for the 30 percent overnight drop in Wall Street stocks in 1987 was heaped on computers. A lot of accounts monitored activity via computer and had programmed the devices to automatically sell a stock when and if it dropped to a certain point. Such "programmed trading" was quickly outlawed.

Stanley Mark Rifkin is arrested on charges related to computer fraud. In 1978, companies had not realized how easy it could be to penetrate a computer system connected to telephone lines.

Stanley Mark Rifkin, a thirty-two-year-old computer consultant, called Security Pacific National Bank in Los Angeles one day in 1978. Using his experience, he transferred \$10.2 million from the California bank to a bank in New York. Rifkin then flew to Zurich, Switzerland, where he purchased millions of dollars in diamonds, paying for them with checks from the New York bank. Security Pacific was unaware of the loss until informed by the FBI several days later!

The diamonds were in Rifkin's possession when he was arrested. He was charged with wire (telephone) fraud, smuggling, interstate transportation of stolen property, and entering a bank to commit a felony. The whole thing had been easy for Rifkin because he had learned about the bank's computer system from business acquaintances. It was easy, too, because Security Pacific handled an average of fifteen hundred cash transfers a day that averaged \$4 billion.

As long as a computer is connected to a telephone, it can be illegally entered. A virus can be placed inside it, set to cause trouble days or even weeks later. Even software makers have to be careful. Aldus Corporation reported in 1988 that hundreds of copies of one of its computer programs had been infected with a software virus. The virus was capable of spreading from one computer to the other, destroying stored data as it went. Aldus learned that the virus was designed by a group of computer owners in Montreal to see how far it would travel.

Keeping Computers (and Governments) Safe

How can you safeguard your own computer? First, never borrow software. Borrowing most software to install it in your machine is illegal, since software must be purchased by each user. Even large companies, such as General Motors, have been caught "pirating" (passing software from one employee to another), but that doesn't make it right. Newly purchased software is the only kind that can be guaranteed virus-free. It also helps to know with whom you're connecting when you use a modem and telephone lines to send or receive information.

There are crimes associated with computers that can even affect foreign policy. Two California executives were sentenced to eighteen months in jail and ordered to pay a $100,000 fine because they sold restricted computer materials to the Soviet Union. At any time, there are nations that might use computer technology to damage another country. In 1977, the Soviet Union was thought to need computer bits in order to aim its missiles. Two Californians, Gerald Starek and Carl Storey, tried without success to sell them to the Soviets by using false papers and setting up fake companies in Canada and elsewhere.

Speaking of crimes, computers give local, state, and federal agents wonderful tools to keep an eye on citizens — whether or not they are guilty of any crime. As early as 1974, President Richard M. Nixon created a Cabinet-level committee to protect the privacy of individuals whose names are in computerized data banks.

International financial exchanges have become reliant on computers for all their transactions. This can lead to sudden collapses in the markets when panics occur and investors all try to sell their shares at the same time.

Software Flaws

At the moment, the biggest problem with the advance of computer technology lies in software. An example is Denver's new international airport. It is twice the size of the island of Manhattan and ten times as wide as London's Heathrow International Airport. It can land three jets at the same time during bad weather, and it has a computerized, underground baggage-handling system that runs on twenty-one miles of steel track. Unfortunately, for months the airport did not work!

An artist's impression of the new Denver airport. Despite all the modern technology that went into the construction of the airport buildings, computer software problems delayed the opening by fifteen months.

Errors in the software controlling the automated baggage-handling system prevented anyone from landing at or taking off from the facility for more than fifteen months. The software system cost $193 million, yet it seemed that no one was able to get the bugs out of it. Because of this problem, backers of the airport lost $1.1 million a day for dozens of days!

Software developers are aware that their industry has problems. For every six new large-scale software systems that work, two others are tried and cancelled. The average software project is almost always late, and the larger the project the poorer the software performs. It won't do Denver much good, but software developers have created software that is gradually improving the way software is made!

Denver isn't the only place with problems. A power outage late in the summer of 1994 left Chicago's O'Hare International Airport without any of its radar or computer functions for an

afternoon. Only the skills of air-traffic controllers and aircraft pilots prevented a disaster. As projects such as space travel or high-speed rail depend more and more on computers, the software must be foolproof. At the moment, it is not. Just ask welfare mothers in the state of Wisconsin.

Scrambled Welfare

A new, $46.3 million computer recently was installed in Madison, Wisconsin, that was designed to help poor people and welfare caseworkers all across the state. It was supposed to eliminate paperwork, speed checks to the needy, and quickly calculate how many food stamps each eligible person receives. It frequently failed. "There are some days when the system just bombs," said one caseworker. Similar software used in Ohio and Florida has resulted in many errors and breakdowns. A state official in Florida called that state's system "a nightmare."

If the Wisconsin computer did not involve society's least able people, it might be funny. Here are some of the things the system has done:

- There are long periods of "down time," periods when the computer simply isn't usable.
- There are long delays between giving the computer a command and seeing that command on a screen. Since a single welfare case can cover as many as one hundred different issues, it can take hours to deal with one person.
- It has mysteriously paid some people more than once and sent too many copies of letters to clients.
- There are few written instructions. And when one problem is fixed, another one is often created.

The software and the consulting fees that went with it total $19.3 million. So far, that investment has not paid off. Horror stories such as the Denver airport and the Wisconsin welfare system will continue until software researchers and manufacturers meet higher standards.

AMAZING FACTS

Employees of Mitsubishi and Hitachi companies pleaded no contest in 1983 to attempting to buy secret IBM technology. The arrests followed a government "sting" operation, where the Japanese executives were videotaped attempting to purchase the confidential information.

Chapter 6
The Future

Imagine this: Your mother is in an important meeting, and you are staying after school to work on the yearbook. Mom promised to pick you up by five o'clock, but her meeting is running late. Without excusing herself, she turns on a watchlike device on her wrist and enters a message. The message is relayed in a fraction of a second to a receiver in your backpack. When you retrieve the backpack from your locker, the receiver is humming, a signal that this message awaits: "I'm running late. Please wait for me at the gymnasium entrance. I'll be there about six o'clock. Love, Mom."

How far into the future is such quick, personal communication? Not very. At the moment, Motorola offers small devices

Computers can help design the spacecraft of the future. These French engineers in Toulouse are working on a hypersonic space plane and a European version of the space shuttle, riding on the back of a jet aircraft.

The interior of an air traffic control room. Computer images help controllers see where airplanes are in relation to each other. They can then tell pilots the safe routes to take.

that send messages through a central computer. You can almost instantly contact whoever has a receiver. The only difference between the Motorola system and the one envisioned above is that the computers are not at some central location but are on Mom's wrist and in your locker. Cost prohibits the widespread use at the moment of personal message equipment. But costs should decrease.

Computers versus Humans

Computers certainly are here to stay. They explore areas of space where man cannot safely go, they calculate problems in seconds that would take an accountant years to solve, they detect an

enemy vehicle past the horizon, and they guide the hand of a brain surgeon. But can they think? An experiment conducted in 1991 was very revealing.

Ten Boston-area residents were picked at random, and they typed back and forth at their computer work stations for three hours. The result? Five of the ten could not tell if they were sending and receiving questions and answers with a computer or a fellow human! But remember, somewhere behind the machine working today, was the person who programmed it originally.

AMAZING FACTS

A computer beat then world chess champion Anatoly Karpov in a match in Berlin in 1990.

Disabled children can communicate with the help of voice synthesizers. The boy controls his synthesizer by using a laser attached to his headband. People who are restricted in the work they can do can often use computers to earn a living.

Conquering Time and Space

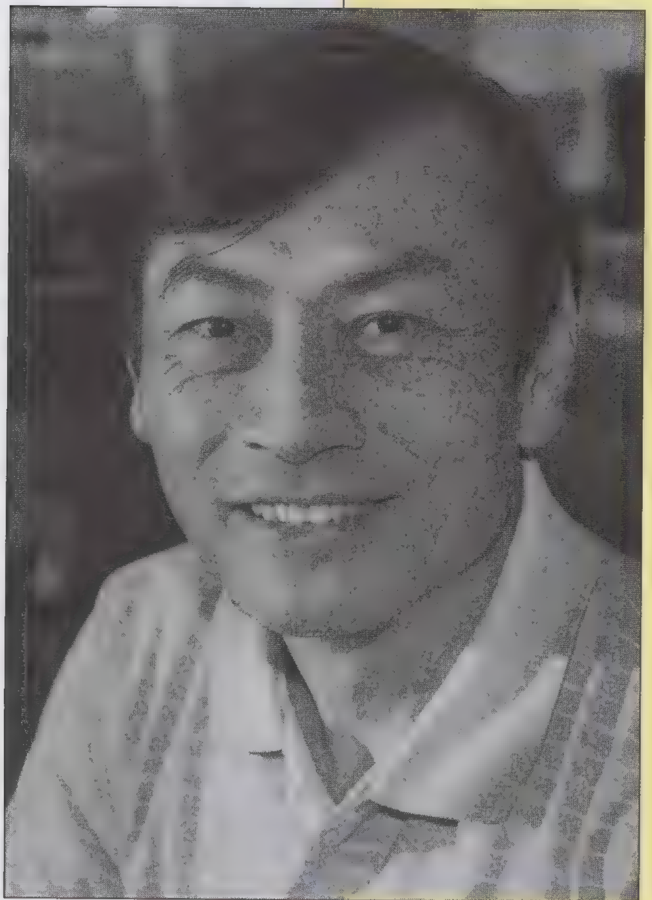
The United States has more than a quarter of a century of experience with using computers to defend our country and explore space. For decades after World War II, the federal government believed that it needed to stay ahead in the arms race with Communist nations. Years in the making and costing millions, supercomputers were used to hurl missiles and other objects into space, to design larger and faster airplanes, and to put an American on the moon. Pioneers in this field included Seymour Cray, a brilliant hermit. Cray's CRAY-1 computer was more than twenty times as powerful as the largest IBM mainframe. CRAYs and similar supercomputers are used today, usually by governments, in everything from weather forecasting to population predictions.

Some tasks, though, are too big for even Cray to tackle. His company decided in 1987 to cancel work on a computer that was one hundred times faster than anything on the market. This caused Steve Chen, the designer of the new machine, to resign. Cray thought the new computer would be too complex to work and Chen did not. One researcher said Chen and his people were "too far out in the ozone layer." In other words, they were so wrapped up in unusual technology that they were nowhere near building the new computer. Chen started his own company but has had financial problems that may prevent construction of a dramatic new kind of computer.

A dynamic random-access memory (DRAM) chip in a wineglass. DRAMs can store a lot more data than static RAMs of the same physical size but need a pulse of power every millisecond to "refresh" their memories.

Steve Chen

Sometimes, working on the invention is easier than doing all the things that go along with it. Just ask Steve Chen.



Chen is the founder of SuperComputers International. The tiny company in Eau Claire, Wisconsin, is struggling to bring to market a very expensive, very fast computer. How fast? The device should be able to make fifty-one billion calculations in one second!

The computer wizard came to the United States after graduating from college in his native Taiwan. He received advanced degrees in computer science at Villanova University and at the University of Illinois. Chen chose his first name when he became a U.S. citizen in 1982.

Steve was hired by Cray Research, Inc., of Chippewa Falls, Wisconsin, after that company realized his talents. Cray is an unusual place — it was founded by Seymour Cray, a virtual hermit and the builder of the world's most successful supercomputer. A supercomputer can perform at least twenty million operations a second, more than the largest commercial computer from IBM or anyone else.

The costly device has other advantages, from improving atomic weapons without having to explode them to more accurately predicting the weather. Steve Chen became one of the first Cray employees, besides Seymour Cray himself, to design a new model.

Chen saw that his employer was doing well, selling as many supercomputers as the firm could make at a price of about $20 million apiece. The Taiwan native wanted to take the process farther than Cray dared go, so Steve left Cray to set up his own company in nearby Eau Claire in 1987.

Because of Chen's reputation, major companies were eager to get his company running. IBM, for example, gave him $134 million.

Other investors included Ford Motor Company, Boeing, and DuPont, each with $22 million, and the U.S. Defense Department, with $20 million. Even the state of Wisconsin was betting on Chen. They provided $1.5 million.

Eventually, the computer wizard produced his first SS-1, a computer that will sell for an estimated $80 million! But it may be too late — IBM, with financial troubles of its own, has no more money to invest. Yet Chen desperately needs more money to perfect such far-reaching ideas as computers that run on beams of light.

Chen must keep up his search for investors while he designs and builds a supercomputer better than Cray or the Japanese firm of NEC or anyone else. Meanwhile, fellow inventors all over the world are designing new supercomputers they hope will be better than whatever Steve Chen comes up with. Who ever said being a computer whiz was easy?

The processor of a Cray supercomputer at the Livermore National Library, California.

Virtual reality can be used to try out options in urban planning and architecture. Here, the impact of proposed highway construction is assessed.

Computers are everywhere in medicine today, and they probably will play an even more important role tomorrow. Miniaturization may allow physicians to "cruise" a patient's bloodstream with a chip so tiny that it can pass through the smallest vein or artery. Such a device could feed pictures to doctors so that they could see the thickness of a blood clot or the exact nature of an injury. That same chip might even help the breakup of small clots that were harmless but could grow. With no more heart attacks or strokes, more humans would reach an advanced age.

What Would Be Left to Do?

Quite a lot. In an ideal world, computers could perform work wherever heat or fumes make things dangerous for human beings. Computerized robot welding arms already work on auto assembly lines and in other cramped or uninviting places. Computers could run an automatic cockpit, aiming cars, planes, or trains safely and surely from one destination to the next. Equally important, computers could calculate exactly how much food and fiber is available for the planet as the population grows. The tasks they perform will be limited only by human imaginations.

That is part of the problem. The human imagination isn't very efficient – it searches for ways to have fun as often as it pursues ways to save the planet. An example is the spread of virtual reality, where multimedia computers make a user feel as if he or she is involved in a real-life experience. A user might pay to climb into an outrageously expensive body suit and be locked into horrifyingly real combat with another body suit wearer a thousand miles away. The suit would make the skin crawl with the threat of danger as the senses are fed sights, sounds, even smells, of a firefight. Is make-believe war a good use of time, money, and technology in a world with real problems?

There is another, very different, worry. If computers take over most tasks, what will we all do to feel that we matter? When computers were first conceived more than fifty years ago, inventors believed that ten of them, placed in major cities around the globe, might be all that was required. Today, in the U.S. alone, there are millions of computers in homes and offices — and they can do things undreamed of in the 1940s. Will they make people feel useless? And will computers become more common than people?

AMAZING FACTS

A map of the human gene system was begun with the help of computers in 1986. Eventually, researchers should be able to pinpoint any hereditary item, good or bad, in human beings. Also in 1986, computer-assisted laboratory work allowed persons to be identified by a substance in each cell called DNA.

Computers and Creativity

Fortunately, several factors will keep the situation sane. First, computers can be controlled in a way human beings cannot. Only humans are creative, conceiving needs and writing programs to fill those needs. Second, many computer ideas will never be realized because of their high cost and because too few people would benefit from them. Third, since there is only so much energy, computers might take a back seat to preserving food, furnishing light, and other needs.

In the foreseeable future, the best single computer project may be completion of the mapping of the human gene system with its three billion characters in a genetic material we all carry called DNA. Once the human gene system is seen and understood, human skills will be needed to help those with genetic flaws live better lives. Computers will be of most help either in the cold vacuum of outer space or in the microscopic areas of living cells. They will continue to work — and play — in our cars, our classrooms, and in our homes.

A gene cluster that is important in transplant rejection is analyzed at a laboratory in France. This is part of the worldwide project to map all human genes.

Timeline

5,000 B.C. — Abacus is invented, probably in China.

1642 — Blaise Pascal invents a mechanical calculator.

1835 — Charles Babbage designs the analytical engine.

1890 — Herman Hollerith's punched cards and tabulating equipment speed the U.S. census.

1937 — Alan Turing publishes a paper, "On Computable Numbers."

1941 — Konrad Zuse assembles his Z3, the first program-controlled calculator.

1943 — Construction of the Harvard University Mark I computer is completed.

1945 — ENIAC, the first fully functional electronic calculator, goes into operation.

1947 — Bell Laboratories invents the transistor.

1948 — England's Manchester University develops the first fully electronic stored program.

1952 — A UNIVAC computer successfully predicts the outcome of the presidential election.

1958 — Jack Kilby builds an integrated circuit at Texas Instruments.

1963 — Digital Equipment Corporation introduces the first minicomputer.

1968 — Intel produces first random-access memory (RAM). This allows a user to retrieve information from anywhere within a computer's vast memory-storage system.

1971 — Intel invents the microprocessor.

1975 — Personal computer age begins with the introduction of the Altair computer.

1981 — IBM enters the personal computer market with the PC.

1984 — Apple introduces the Macintosh.

1994 — Smaller, less expensive computers with powerful chips, labeled Pentiums or Power chip PCs, are offered for multimedia computer use.

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Glossary

Abacus: A hand-operated computing device made of a frame, rods, and beads, used to add, subtract, multiply, and divide large numbers.

Artificial intelligence: Humanlike thought by computers.

BASIC, COBOL, FORTRAN: Languages that substitute words and symbols for numbers, used to program computers.

Binary numbers: A numbering system with two as its base. Computers are programmed using two binary numbers, *0* and *1*, representing open or closed electrical paths.

Calculator: A machine with a keyboard for automatic addition, subtraction, multiplication, or division.

Computer: A machine that performs high-speed mathematical or logical calculations. Computers also gather, store, process, and produce information.

Electronic mail: Sending messages from one computer to another, using devices called modems to send messages through telephone lines.

Integrated circuit: Many tiny devices connected in an electrical path on a single chip of silicon or other material.

Microprocessor: A fingernail-sized computer chip made in part of silicon.

RAM: Random-access memory. Computer memory that allows data to be accessed directly rather than following a sequence of storage locations.

ROM: Read-only memory. Memory that can be read but cannot be altered.

Semiconductor: Any substance, such as silicon, that is a better conductor of electricity than an insulator but not as good as a conductor.

Silicon: A nonmetallic element, found in sand, that is used in the making of microprocessors.

Software: Written or printed programs that operate computers.

Transistor: A small electrical device made of silicon. Smaller and faster than a vacuum tube, the transistor was used in computers before the microprocessor.

Vacuum tube: An empty glass tube through which electrical current moves. Later replaced by the transistor.

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